Complementary Strategy for Reducing Integument Heating via the Prevention of Initial Acoustic Generation in Hypersonic Aircraft in Supplement to Recently Proposed Unidirectionality of Acoustic Flow System

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Introduction

The heating of an aircraft's or missile's skin has its ultimate origins in the acoustic energy infused into the integument of the aircraft's or missile's skin by way of friction with the air. Facilitating the more efficient flow of heat and sound through the skin of the aircraft or missile aids the prevention of the excessive accumulation of heat. However, the prevention of the initial formation of the acoustic energy resulting from that friction, when combined with the aforementioned strategy, complements the first strategy and can enable even cooler operating temperatures of hypersonic aircraft than possible using one strategy in isolation. Absent has been a strategy for preventing that initial formation of acoustic energy.

Abstract

Although drag is determined primarily by the velocity of an aircraft or missile (in addition to the density of the fluid it is traversing,) friction is not always proportional to drag. Heat generation in the integument of aircraft and missiles is, however, proportional to friction. It is possible, therefore, to take measures that reduce this acoustic generation without actually reducing drag. Drag need not be reduced to reduce friction. Therein lies the folly of aerothermodynamic researchers focusing exclusively on drag reduction.

Not to be confused with the concept of a Pulse Detonation Engine, a novel approach involving generating supplementary pulses of thrust of a modest nature using a secondary thrust generation system in addition to the primary thrust generation system can reduce acoustic generation in an unexpected way.

Drag is agnostic to rate of acceleration. Therefore, applying a comparatively mild pulsed thrust (of perhaps only 1/200th of the thrust of the primary engine) in addition to primary thrust would do nothing to increase drag. To understand why this would have a noise-reduction benefit for the integument, consider the analogy of the drum and the drumstick.

A great many air molecules bombard the skin of an aircraft or missile, striking like individual drops of rain on a roof, generating quanta of sonic energy which, in the aggregate, amount to a white noise. These air molecules never strike the skin in unison. This is due to the random distribution of the air molecules in the atmosphere. When a drumstick strikes the membrane of a drum, it can generate sound because only one small section of that membrane is perturbed. If one

were to somehow strike the membrane of that same drum with a flat object so that every part of it were contacted in unison, very little sound would be generated at all. Importantly, what acoustic energy is generated from that sort of impact has a different characteristic of flow through its medium, leading to far less heating associated with the passage of that noise through the medium. In seismology, this is the difference between an S wave and a P wave. Pressure waves take a more direct route through a body and therefore have fewer opportunities for conversion into heat whilst traversing the medium.

By providing auxiliary thrust pulsed with sufficient rapidity, air molecules near the integument can be made to, at least half of the time, strike the skin in synchronized, unified, waves, not unlike how a sheet of rain can be formed by taking a piece of cardboard and pushing it up against the falling rain and quickly pulling it aside.

These unified waves would form during the "off" phase of the auxiliary thrust as the aircraft's acceleration vector and/or speed would fractionally decrease, creating temporarily an area of reduced pressure in the area ~1mm in forward of the integument. Surrounding, higher-pressure air would move in to fill the void (not a true void, but an area of reduced pressure) and would naturally, therefore, be brought into alignment with one another, assuring that the integument is struck by the resultant walls of air in unison. These walls of air would inject little acoustic energy into the integument and may even negate acoustic energy already injected during the alternate phase of the auxiliary thrust system.

Conclusion

This strategy for reducing friction is one not without precedent in nature. The woodpecker, for instance, utilizes a strategy of rapidly alternating between incursion into and withdrawal from the wood of trees. In the case of the woodpecker, that strategy has more to do with the economy of energy than with heat reduction. However, if one were to perform a study into the temperature of a woodpecker's beak in comparison to a conventional drill bit performing the same work, one would find that the woodpecker's beak maintains a markedly lower temperature and one would furthermore find that this is due to differences in the nature of the acoustic input into its beak i.e. they consist more of P-waves than S-waves.

Both this strategy and the strategy of mentioned in the prior publication would be best-utilized in concert with one another as part of a novel missile design. The ability to field self-fueling hypersonic missiles with infinite-loiter capacity would yield substantial strategic benefits, making this approach of phonon genesis prevention and acoustic flow directionality control one deserving of immediate investigation.